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AFIT/GEM/CAE/90S-12

A MANPOWER REDUCTION MODEL FOR
THE MARINE CORPS SECURITY FORCES

THESIS

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AFIT/GEM/CAE/90S-12

The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

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THESIS

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Preface

The purpose of this study was to develop a mathematical model for forecasting the specific billets which should be reduced in a Marine Corps Security Force Organization once a quota is directed. The mathematical model allows weighted criteria to be incorporated into the reduction equation. A sensitivity analysis shows how the limits of the model variables can affect the optimum solution.

Faced with constructing a prototype and purposely constraining it for micro-computer application, I relied essentially on existing data for input. The model relied on data available for Marine Barracks, Subic Bay, Republic of the Philippines. The prototype concentrated solely on functional constraints. The logic and data for the problem are intended to straightforward.

In constructing the model and writing this thesis I have had a great deal of help from others. I cannot adequately express my gratitude to my advisor, Professor John Muller, who generously shared with me his knowledge and wisdom. He was a source of support and sound advice. I would also like to thank Mr. Robert Halayko, of the US Army Engineer Studies Center, for assistance with the model. His generosity in allowing me to refine his methodology for my application was extremely valuable. Finally, I depended more than she realizes on my wife Cindy, for her extraordinary patience and encouragement.

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Abstract

The United States Marine Corps has a charter to restructure manpower. The charter is the primary result of a change in command philosophy about how the Marines wage war but is tempered within the constraints of a declining force. The reduction and redistribution of forces are important issues. This study investigated the Linear Programming technique as a methodology to forecast billet reductions in one Marine Corps organization.

The mathematical model allows weighted criteria to be incorporated into the reduction equation. A sensitivity analysis shows how the limits of the model variables can affect the optimum solution. The general capabilities of the model were indicated when data from the Marine Barracks, Subic Bay, Republic of the Philippines were tested across four manpower planning cases. The model was formulated on existing management science software so local commanders can use the model at their unit.

Although the prototype did not reproduce planned reductions the model illustrates the type of information and analysis that is possible.

A MANPOWER REDUCTION MODEL FOR THE MARINE CORPS SECURITY FORCES

I Introduction

Overview

This chapter discusses the use of a manpower reduction model for Marine Corps Security Force manpower planning. The background of the manpower planning environment is presented first. Next, the research problem, the purpose of the research, the justification for the research and a declaration of the scope and limitations of the research are stated. The chapter concludes with a listing of the investigative questions pertinent to the research.

Background

The United States Marine Corps has a charter to restructure and reduce manpower. The charter is the primary result of a change in command philosophy about how the Marines wage war. Since taking command of the Marine Corps in July 1987, General Alfred M. Gray Jr. has reemphasized the primacy of warrior virtues and set forth a new philosophy that is revolutionizing the Corps (9:17). General Gray's initiatives are tempered within the constraints of a declining manpower force.

Secretary of Defense Cheney is faced with definite cuts in military manpower. Cheney's budget proposals leave a

large gap between what the administration wants to spend and what Congress appears willing to authorize. The House has passed a 1991 budget resolution with just $283 billion in military spending authority, and the Senate Budget Committee has proposed $285.6 billion (25:4-A). Both are short of the $306.9 billion sought by the administration (25:4-A).

Congressional budget resolutions would force the Defense Department to cut more than 140,000 uniformed personnel next year, instead of the 38,000 planned. A complete analysis of the manpower reduction picture is presented in Chapter 2.

One of General Gray's early initiatives was to make significant changes in how the Marine Corps distributes its people and functions between the active duty forces and the reserves, and within the active force (9:17). Previously, the Marine Corps had kept the supporting structure (boot camp, supply depots, and repair facilities) relatively strong while much of the combat force was underfunded or undermanned. The theory is that, if war comes, a strong support base can turn out combat troops quickly enough to meet requirements while a weak base may result in disaster.

General Gray's initiatives enact his philosophy that it is counterproductive for the "combat forces" to be weakened at the expense of a strong support base (9:17). The General determined that combat forces would have foremost priority from now on. Selected combat units would be maintained at full strength thus presenting a juggling act for personnel

planners who can only work within the present Marine Corps manning levels.

Statement of Problem

The Marine Corps Security Forces, although responsible for security aboard Naval installations and vessels, do not fall in the category of units that will be maintained at full strength. As part of the restructuring effort, the Security Forces were required to reduce manpower levels by three percent (1). The methodology for determining which billets to reduce was qualitative. Security Force experts based their decision on knowledge and interpretation of doctrine and regulation. The problem is that no mathematical model exists, in the Marine Corps, which could impart objectivity in the decision making process (14). Senior officer recommendations should be worthy of acceptance. The key is that the final solution could be enhanced by an analytical methodology.

Purpose

The purpose of this study is to develop a mathematical model for forecasting the specific billets which should be reduced in a Marine Corps Security Force Organization once a quota is directed. The mathematical model will allow for weighted criteria to be incorporated into the reduction equation. A sensitivity analysis will also show how the limits of the model variables can affect the optimum solution.

Justification

As late as 1987 a career Department of Defense Manpower Management Officer, in a videotaped brief to unit commanders, stated "I'm not aware of any place 'the thought process on how to take a cut' is written (32:9)." The officer argued that luck was an important factor and perhaps the reduction requirement would come down by grade and occupational field. The same situation exists today. Once a quota is established by higher headquarters it is incumbent on field commanders to then wisely determine which billets will be reduced. The commander may leave mission areas alone and only hit the support areas. A second approach is to leave those units who took a hit last reduction alone and reduce all others. A third way is to further reduce on a fair share basis.

The manpower management officer's omission of a scientific method strongly implies one does not exist or if it does is not valid. Although the manpower management officer was not in the Marine Corps, similar situations exist in the other services. A primary assumption for this research is the absence of a scientific technique for manpower reduction in the Marine Corps Security Forces. This researcher has first hand knowledge and can verify that no scientific technique was employed. Initial research indicates a scientific technique for DoD manpower reduction has been developed (10;11;22;23). A primary justification is to impart validity and reliability to the systematic inquiry

already attempting to solve the general manpower reduction problem.

Another reason for conducting the research is strictly economic. Economic justification is essential for countering the critique that qualitative analysis is sufficient in this decision making process. After all, commanders are selected for their leadership and managerial wisdom. The authority and responsibility of command justify a decision and any bias inherent to that decision. There are, as in this manpower reduction scenario, decision making processes where the commander of a Marine Corps Security Force is only one influence among many (1). The consolidation of the many influences in one quantitative analytical tool can possibly reduce personnel expenses associated with the present methodology.

The Marine Corps Security Force Commanders, because they are under the operational control of the Navy yet under the administrative control of the Marine Corps, submitted reduction recommendations to a Headquarters Marine Corps team that travelled to the Security Force location and physically validated the recommendations. The Headquarters Team, after review, submitted the final recommendation to the Chief of Naval Operations. The Chief of Naval Operations then mandated the reductions (1).

The travel of a Headquarter's team to an operational organization is a common occurrence. The justification for travel includes validation, inspection, and establishing

rapport. Herein lies a major justification for the mathematical model. It can provide a validating tool that Headquarters can use without the expense of travel. The local commander's priorities can be factored into the reduction model and an optimum solution obtained at the Headquarter's level thus freeing travel funds for other endeavors. Although rapport may suffer as Headquarter's teams may no longer have the need to visit field organizations, the premise of this researcher is that declining operational funds in the armed services will find restricted travel a given--therefore the productivity gained from model implementation will be further magnified and far outweigh the loss of any rapport.

Scope and Limitations

The scope of the study is to develop a manpower reduction mathematical model that the Marine Corps Security Forces can use on notification of further cutback quotas. The study will be limited to the Marine Corps Security Forces because of the researcher's familiarity of the situational variables. Access to all data for this organization is available to the researcher.

The model is to be formulated for use on a microcomputer with existing operations science software. This limitation is purposely built in so that commanders can use the mathematical model at their unit. The model will employ the Marine Barracks as the minimum organizational level capable

of analysis. A Barracks is the most basic self sufficient Marine Corps Security Force organization and thus has the personnel, intelligence, operations, and logistics capability to formulate, analyze, and implement a manpower reduction model.

Investigative Questions

The investigative questions that will narrow the topic to make it researchable are as follows:

1. What are the management science approaches to the Marine manpower problem?

2. What in-house methodologies are currently employed to arrive at recommended cutbacks?

3. Why are the present methodologies used?

4. What are the various managerial science techniques that meet the requirements for employment?

5. Can constraint variables be identified and, if so, are they linear or non-linear?

6. Is the expertise for model formulation resident in the Marine Corps?

7. Is it cost-effective to train Marines in management science techniques or is it better to use outside agencies for model formulation, solution, and implementation?

8. How can a cap on manpower reductions be estimated for an organization?

Summary

This chapter presented background material on the present Marine Corps Security Force manpower planning environment. The problem underlying the proposed study was identified along with the purpose of, justification for, and scope and limitations of the research. The ultimate goal is to provide an unbiased management tool that unit commanders and higher headquarters can use once reduction quotas are generated.

II Background

Overview

This chapter discusses the political and budgetary processes that result in Department of Defense manpower reduction requirements. Manpower reduction is only one aspect of many cost saving measures the Bush administration will employ in reducing the federal deficit. After meeting with Congress on June 26, 1990, President Bush stated:

> It is clear to me that both the size of the deficit problem and the need for a package that can be enacted require all of the following: mandatory program reform, tax-revenue increases, growth incentives, discretionary-spending reductions, orderly reduction in defense expenditures and budget process reform. (17:3)

This chapter will describe federal deficit reduction plans and recap the impact of Gramm-Rudman legislation on the federal deficit. The effect of the "peace dividend" to reduction initiatives will be discussed. Defense plans in the deficit control process will be presented and a focus on the Marine Corps requirement to reduce manpower will conclude the chapter.

Deficit Reduction Plans

Maze indicates White House and congressional budget negotiators tentatively have agreed to limit deficit reduction next year to about $55 billion (18:20). The effort is part of a short term plan for setting federal spending levels for the fiscal year that begins October 1, 1990. Maze argues negotiators hope to arrive at a longer range

plan to change the budget process (18:20). The negotiators are participants in a budget summit where the focus is on how much money can be saved by spending cuts or new taxes.

Maze concludes that by agreeing to reduce the deficit more gradually than the $64 billion required by the 1985 Gramm-Rudman deficit-reduction legislation, the negotiators in effect decided to change the law (18:20). The change however did not divest the government from being forced to cut spending or raise taxes next year. Less spending or increased taxes is required by Gramm-Rudman, to meet the 1991 budget target. As Rankin attests, the Bush administration has submitted a deficit-cutting package that includes tax increases (27:8-A). Rankin surmises President Bush, in an attempt to drive the deficit down, agreed to tax measures to placate the Democrats who control Congress (27:8-A).

Rankin similarly supposes that other congressional leaders are concerned the economy will suffer from either the massive cuts in federal spending or the substantial increase in taxes needed to achieve deficit reduction requirements (27:8-A). Rankin implies that not implementing tax increases could lead to recession which may make reelection difficult for President Bush in 1992 (27:8-A). Rankin, conversely, echoes the concerns of other analysts that raising taxes now also would risk recession unless the Federal Reserve Board offsets the economic impact by lowering interest rates (27:8-A).

The Federal Reserve Board met July 2, 1990 to determine if rates would be cut (27:8-A). The basic problem is that U.S. economic growth is sputtering (27:8-A). The economy grew at a below-average 1.9 percent annual rate from January through March (27:8-A). Rankin's summation of analytical views is that such weak tax growth is yielding tax revenues far below what was projected the first eight months of fiscal 1990 (27:8-A). Meager revenues combined with increasing costs of the savings and loan bailout, Rankin concludes, threatens to raise the federal deficit (27:8-A).

The Bush administration's original $101 billion dollar budget submitted to Congress in January projected the government would have to find $37 billion in either spending cuts or increased taxes and other revenue to meet a $64 billion Gramm-Rudman target (18:20).

Maze found that Richard G. Darman, Director of the Office of Management and Budget, warned that the economic forecast had changed (18:20). Instead of a deficit of $101 billion as originally predicted, Maze indicated the weakened economy, increased inflation, higher interest rates and the larger-than-expected cost of the savings-and-loan bailout could make the 1991 budget deficit as high as $230 billion (18:20). Rankin indicates the deficit was $152 billion in 1989 and it may reach $195 billion this year (27:8-A).

Rankin maintains the present Federal Reserve Board policy is to keep interest rates high (27:8-A). The aim is to reduce inflation. Inflation has remained persistent,

however, at about a 5 percent annual rate (27:8-A). Rankin's analysis is that Board members oppose rate cuts as inflation has not decreased (27:8-A). Rankin concludes that meager economic growth might persuade the Federal Reserve Board to cut rates slightly at the meeting on July 2, but Bush's switch on taxes alone will not move the Board to action (27:8-A).

Gramm-Rudman Impact

Under Gramm-Rudman law, cuts may be spread across defense and domestic programs if the overall budget adds more than $64 billion to the national debt (18:20). For defense, this could force a $83 billion 1991 spending reduction (18:20). The potential Gramm-Rudman cuts are presented in Table 1.

Table 1.
Deficit Cuts

Under the 1985 Gramm-Rudman Law, if the fiscal 1991 deficit exceeds the $64 billion target, there will be automatic, across-the-board cuts to meet the target. Half the cuts come from defense programs and half from domestic discretionary programs. Current estimates of the kind of cuts necessary to meet the Gramm-Rudman target show:

If the deficit is:	the overall budget cut would be:	meaning a defense cut of:
$101 billion	$37 billion	$18.5
114	50	25
139	75	37.5
164	100	50
199	135	67.5
230	166	83

(18:20)

Planning thus must consider the potential for excessive cuts. Price quotes Defense Department analyst Richards,

after Richards briefed visiting Daytonians on the Pentagon's plan for 2 percent reduction in inflation-adjusted spending in each of the next five years: "There's nobody within ten miles of the sound of my voice who believes that's really going to happen" (26:7-A).

Price demonstrates that the administration's budget is only a starting point from which Congress will trim as they formulate 1991 spending legislation and develop long term plans (26:7-A). Price writes that former Defense Secretary Robert McNamara said the defense budget, adjusted for inflation, could be cut in half over the next decade (26:7-A).

The administration asked for $306.9 billion in the 1991 budget proposal sent to Congress in January (26:7-A,18:20). The proposal was up from the $301.6 billion for 1990, but a decline of about 2 percent in real purchasing power when adjusted for inflation (26:7-A,18:20).

Price concludes Secretary of Defense Cheney plans on saving money by reducing or postponing twenty weapon development programs (26:7-A). Cheney also froze the start of new military construction projects, proposed cancelling some and produced a list of military installations to close (26:7-A). Table 2 portrays how Cheney would restructure the military if forced by Congress to make a 25 percent force structure cut by October 1, 1995.

Table 2.
Cheney Reduction Plan

	Current	Cheney's 25% cut plan	Change
Military personnel(in thousands)			
Active Duty	2,077	1,635	-442
Army	744	520	-224
Navy	591	501	-90
Air Force	545	466	-79
Marine Corps	197	148	-49
Guard and Reserve	1,155	895	-260
Army	757	515	-242
Navy	153	151	-2
Air Force	201	185	-16
Marine Corps	44	44	0
Strategic Forces			
Peacekeeper missiles	50	50	0
Minuteman missiles	950	500	-450
Poseidon-Trident missiles	576	480	-96
Strategic bomber sqdrns	21	17	-4
General purpose forces			
Army divisions	32	22	-10
Total naval vessels	566	455	-111
Aircraft carriers	14	12	-2
Battleships	4	0	-4
Combatants/subs	307	228	-79
Lift and Aux. ships	65	47	-18
Air Force fighter wings	36	25	-11
Navy attack wings	15	13	-2
Marine Corps wings	4	4	0
Air Force B-52 sqdrns	3	2	-1
Strategic airlift sqdrns	25	25	0
			(16:4)

The *New York Times* describes Cheney's presentation as a signal of an emerging consensus between the Bush administration and congressional experts (3:14-D). The Pentagon's official view, according to the *Times*, is the plan is only "illustrative" of the kind of reductions that are being

considered and was not a formal proposal (3:14-D). Cheney submitted the presentation in response to a congressional request about the budgetary effects of a 25 percent reduction of military forces (3:14-D).

Maze argues the presentation, rather than being the Pentagon's recommended method of cutting military spending, is more likely intended as a defense against large cuts in the administration's budget request (16:4). By showing congress how such a reduction would result in base closings and defense worker layoffs, Maze asserts that Cheney might be trying to persuade lawmakers that big cuts would be politically dangerous (16:4).

Supporters of Secretary Cheney's analysis include Senator John W. Warner, Republican-Virginia, ranking Republican on the Senate Armed Services Committee. Maze states that Warner is convinced that any attempt by Congress to cut the defense budget significantly next year would be "absolutely disastrous" for career service members because large cuts in military spending cannot be made quickly without reducing personnel levels (16:4). Senate Armed Services Committee Chairman Sam Nunn, Democrat-Georgia, was also optimistic. On the work done on a long range plan Maze quotes Nunn as saying "In that sense, it is real progress" (16:4).

Some of the "illustrative" force levels in Cheney's study, 22 active Army divisions, 450 Navy ships and 25 Air Force fighter wings, according to the *New York Times*, come close to recommendations made by Pentagon critics (3:14-D).

By providing specific illustrations of cuts that go beyond what the military services have proposed, the *Times* indicated Cheney had signaled that reductions of that magnitude are feasible without jeopardizing U.S. security (3:14-D). Although Cheney concedes that the 25 percent plan "generally tracks" with ongoing Pentagon plans, Maze asserts that Cheney said he only drew up the 25 percent plan because Congress asked for it (16:4).

<u>The "Peace Dividend"</u>

Cheney's plan was also configured in response to the rapidly changing international order. The *New York Times* describes the plan as "the most comprehensive picture on how the military should be reshaped in light of reduced East-West tensions" (3:14-D). While not specifically presenting a global strategy, the *Times* concludes that Cheney's plans signify a reduced need for heavy Army ground forces and air units in Europe, and place more emphasis on lighter, more mobile combat units (3:14-D).

Cheney has formulated his reduction plan with a cautious view of recent Soviet events. Matthews, describing an April 11 speech to an organization of women lobbyists and midlevel government officials, states that Cheney warned it is too soon to "cash in the chips of the peace dividend" (15:6). Matthews argues that Cheney views the Soviet Union as the only nation that possesses the capacity to destroy the United States but realizes as well that it is unlikely that

the former Soviet satellites, would willingly join the Soviet Union in an attack on Europe (15:6). "But we still have a long way to go" before it is clear that the changes in the Soviet Union are more than superficial, Cheney said (15:6).

Matthews says Cheney believes the United States should not make major defense cuts until the treaties on conventional forces in Europe and strategic arms limitations have been signed, Soviet troops have been withdrawn from Eastern Europe, and democratic elections have been held in the former Warsaw Pact nations (15:6). Matthews does say that Cheney is optimistic about the direction of events and believes that changes in Eastern Europe have gone further than Soviet leaders ever expected (15:6).

Matthews' interpretation is that Cheney believes changes probably were begun in the expectation that they would save communism (15:6). The changes led to the unanticipated fall of communist regimes throughout the Warsaw Pact.

Cheney cautions that the Soviet woes serve as an indication of expected American troubles in manpower and weapons reductions. Matthews states Cheney's argument is that the Soviets may be having trouble coping with the military cutbacks needed to salvage their economy (15:6). Cheney said "They are having trouble absorbing even the 500,000 troops that they recalled in December, 1988" (15:6). Cheney directs attention to the heavy government subsidy that is afforded to Soviet officers. Officers and their families

are paid, housed and educated by the military (15:6). Cheney argues the capacity of non-military sectors to absorb them is limited (15:6). The Soviets hope to convert some factories that produce military hardware to produce civilian goods but Cheney says "are finding it very difficult to do so" (15:6).

Complying with conventional forces treaty requirements, also will be difficult for the Soviets. They must destroy 30,000 tanks to reduce their force to numbers expected to be allowed by the treaty. The task is considered massive by Cheney (15:6). Cheney decreed the task easier for the United States, but not to be accomplished without discomfort (15:6). The defense budget is expected to shrink by $231 billion over the next five years. "We've still got a long way to go to identify all of the things to be cut in '92, '93 and '94," Cheney said (15:6). "The cuts that have already been made will be relatively modest compared to what's in store," Cheney concluded (15:6).

Manpower Plans

The proposals still leave a large gap between what the administration wants to spend and what Congress appears willing to authorize.

The House has passed the 1991 budget resolution with $283 billion in military spending authority, and the Senate Budget Committee has proposed $285.6 billion (25:4-A). Cheney told a Senate panel on June 12, 1990:

> The only place we could get those kinds of savings quickly in fiscal 1991 is our manpower. There's no other place to go. We'd have to run a lot of people off, throw people on the street, freeze promotions (12:12-B).

Cheney argues such action would be viewed as a "break of faith" between career oriented personnel and the government (15:6). Cheney thinks it would be difficult in the future for the Defense Department to attract people to the all volunteer force when they see the bleak advancement (15:6). Price argues the picture is a result of the congressional budget resolutions which, upon Cheney's interpretation, could result in a cut of more than 140,000 uniformed personnel next year, instead of the 38,00 planned (25:4-A). The resolutions also would force cuts in training, maintenance, operations, research, and development.

Price states Pentagon officials have said that much of the planned personnel cuts could be handled through attrition but that the congressional resolutions would require 65,000 to 90,000 involuntary separations next year (25:14).

Marine Corps Manpower Requirements

Prior to the announcement of Secretary Cheney's 25 percent cut plan, when reduction figures were less, General Gray warned Congress that cutting the Marine Corps by 40,000 troops would "seriously disrupt" the structure and usefulness of the service (5:6).

"Generally speaking, you're talking about cutting a third of your operating capability out of your expeditionary

forces", Gray said June 12 before a subcommittee on projection forces and regional defense (5:6). Gray asked:

> One would have to say to the unified commanders, what third of the world would you like to have less presence, less capability, less flexibility, particularly if there were more than one crisis at the same time? (5:6)

Gray was responding to questions about the potential impact of the 25 percent cut in manpower all services could sustain as part of the five-year budget plan then being examined by the Pentagon (5:6).

The cut would reduce the number of Marines from about 197,000 to about 148,000 (16:4). If cuts must be made, Gray said, the Corps' end strength should go no lower than 180,000 (5:6).

He also said the service should come down by no more than 7,000 Marines a year to ensure an orderly transition "in which you protect readiness and preparedness and [which] permits you to treat your people with dignity" (5:6).

Summary

Lawmakers involved in budget talks say a final agreement that will determine spending levels for the Department of Defense is a long way off. Manpower reduction is certain to be reactive rather than proactive until budgetary figures are determined. Manpower planners realize that worst case scenarios are possible. Compensation programs that are before Congress indicate the compassion that lawmakers and defense department officials have for the reducing workforce

(19:3). Planning efforts seem to encompass organizational concerns with due concern for the individual.

The manpower reduction model presented herein is formulated as a simple yet effective approach to planning in the reduction environment. Planners at the lowest organizational level, when directed to reduce their workforce or in anticipation of reduction quotas, may use the model to identify specific billets that can be eliminated. The model uses existing management science methodology available on micro-computer software applications. The intent is to contribute to existing manpower forecasting techniques and identify the capability of the Linear Programming approach to reduction scenarios at the basic organization. The model does not detract from planners' expertise and experience but rather adds a managerial assistance tool to their decision making repertoire.

III Methodology

Overview

This chapter discusses the methodology necessary to implement a mathematical manpower reduction model. A literature review of manpower models will be presented. A justification for the modeling approach will also be included. A systems analysis will outline the model and the model will then be formulated and applied.

Literature Review

The literature on manpower planning models is extensive. Successful applications of models have been reported and much of the literature is mathematical (4;20). Several useful reviews of corporate and defense department manpower planning models have been developed (10;11;23;24).

Models are usually designed to forecast manpower assets over time. With the exception of linear programming models, these models are more descriptive than prescriptive. The prescriptive models are entirely devoted to future manning requirements. Niehaus, Grinold, Marshall, and Halayko appear to be the only Department of Defense manpower planners to work the mathematical modeling technique from a retrospective view (10;11;23;24). They assumed a steady state condition and then forecasted reductions required by an outside factor. Most manpower models forecast a future manning strength with growth as a key assumption to the model.

Brief descriptions of the main types of models are given in Table 3:

Table 3.
Common Models

1. *Steady State Models* These calculate an ideal distribution in which constant career patterns are maintained over time. Assumptions include uniform growth. 2. *Markov Chain Models* Flows of employees between different groups or states in a given period of time are expressed as a matrix of transition probabilities. Groups or states may be defined in terms of grades or levels, sex, age or skills. The manpower structure at the end of a time period is calculated from the initial structure by applying the matrix of transition probabilities and adding any recruits. Repeated application of the matrix gives the manpower structure in future time periods. 3. *Simulation Models* A form of 'renewal' model where future manpower requirements are assumed to be known and the need is to promote and recruit individuals to meet manpower requirements in the future. Flows of employees resulting from retirement, promotion, and recruitment in a given time period are modelled explicitly. In its simplest form, all data is deterministic producing one 'scenario' of the future manpower structure. 4. *Linear(Goal) Programming Models* Manpower structure and flows are expressed as a system of linear equations and linear constraints. An objective function to be optimized must be specified. Goal programming permits simultaneous specification of a number of criteria to be satisfied, but still requires priorities to be assigned to each criterion. (29;89)

Justification

Emory argues the term 'model' has gained such popularity that it threatens to become an all-purpose word for relationships among concepts (7:31). This is because models can represent many things physical, symbolic, or mental. A monkey tested with new drugs is an example of a physical model. A simple linear programing problem is a form of a mathematical (symbolic) model. A decision made and the rationality behind it is an example of a mental model. In a

broader sense, models may be linear or nonlinear, discrete or continuous, and stochastic or deterministic.

Perhaps a better definition which can be applied to this research is given by Neelamkavil. He describes a model as a simplified representation of a system (or process) to enhance our ability to understand, predict, and possibly control the behavior of a system (22:30).

Neelamkavil's definition places the justification for this research in proper perspective. The goal and emphasis of this research is on exploring and understanding manpower reduction issues through a prescriptive technique. The primary justification is that the model will assist the evaluation of problem alternatives without actually conducting people experiments.

The strengths of a model make it popular among researchers. Models have an economic strength for they parallel reality at a minimum time cost. A researcher can see results almost immediately without having to deal with this constraint. Models are also ideal for sensitivity analysis. The limits for variables and results can be readily identified. Models are quite flexible. A model may be suited to many problems without too much change in its form. Similarly, different and distinct models can often be applied to one problem. Validation occurs when more than one model is successfully applied. Problems may even be anticipated and avoided and contingency plans can be drawn for certain eventualities. A very important advantage is

the clarification of a situation. A model provides a sound insight of a functioning system when that system can be structured.

All research cannot be modeled. Herein lies the major weakness. The complexity of many situations precludes a modeling scenario. The availability and quality of data may discourage modeling. Data quality is important as it dictates the usefulness of the analysis. Detail cannot be incorporated in the model if the data is not precise. Detail is paramount to reliability. Coming full circle, the reliability of the model output would then be limited by the reliability of the data input.

Other weaknesses are costs that cannot be minimized. The cost of establishing the model and keeping it current are real and will increase with the size of the system. Maintaining the database and analyzing output are continuous costs. A related weakness is the complexity of communication required to keep the model current. The model may not function as originally intended and may become invalid if there is not good communication (between the modeler and the modeled entity). Certain weaknesses arise whenever there is a human factor. Skills and ability are hard to quantify. Interpretative variables can lead to interpretative vice definitive conclusion.

Modeling is an interactive process and thus requires a methodology itself. According to Neelamkavil the most important phases in the modeling process are definition of

the problem, systems analysis, formulation of hypothesis, formulation of a simple specific model, verification, validation, documentation, and implementation (22:30).

A systems analysis will identify the interaction of the various manning levels within an organization. For the Marine Corps Security Forces, manning levels can be organized across three distinct groups. The groups consist of guard personnel, support personnel, and command personnel. The three groups are stratified horizontally and vertically. Explanations for the stratification and the relationships between the stratifications will be the primary focus of the systems analysis.

The specific model for this research will be a simple linear programming minimization model. The linear programming concept is a theory which has wide applications and can be applied to the reduction scenario (2). The simplex algorithm technique will determine the set of operational rules for the linear programming concept. The concepts and techniques of minimization, and the desire to reduce the impact of lost billets will assist in forming the real world Security Force manpower system.

The system entities, their attributes (parameters and variables), the system's boundary and system's environment are isolated and recorded in Table 4 and Figure 1.

Table 4.
System Entities and Attributes

Entities	Attributes
Manpower	Billets, quantity
Firepower	Weapons, ammunition
Time	Interval
Organization	Type, size

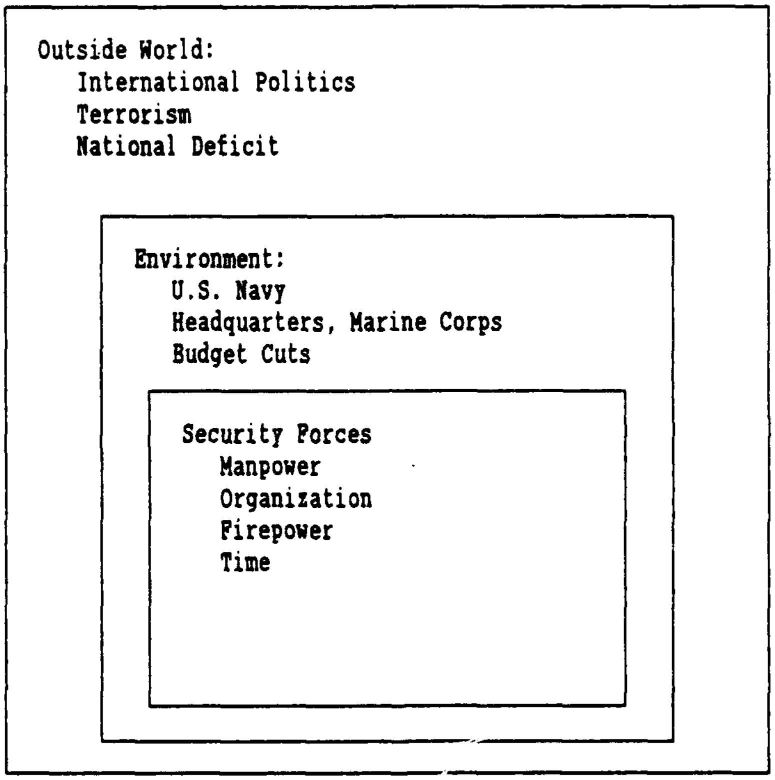

Figure 1.
Security Force Environment

Relevant data will be collected and analyzed for general patterns. The Security Force manpower system will be analyzed very carefully to identify potential candidates for parameters, interrelationships, constraints, goals, measures

of effectiveness, and methods of solutions. Possible candidates are:

Goals:

minimize reduction by billet; minimize reduction by military occupational specialty; minimize reduction by organization; minimize reduction by geographical area;

Measures of effectiveness:

optimum of a risk function expressed in terms of reduced manpower levels; optimum of a function which describes the geographical area differences by reduced manpower; optimum of a function expressed in terms of lost firepower; optimum of a function which incorporates both tangible and intangible benefits expressed in terms of mission effectiveness. (Note: The use of the term "optimum" can be represented by a function's minimum point which will produce the best decision value).

Interrelationships:

important versus unimportant; continuous versus discrete; controllable versus uncontrollable variables; availability of men, money, and time; period of study; limitations of data; political influences; assumptions.

Solution strategy:

methods for the collection and analysis of data; estimation of parameters; linear versus nonlinear model; computational methods; generality, applicability, and flexibility of solutions; possible extensions.

The emphasis will be on simplicity, computational efficiency, and a reasonable degree of accuracy. Only the minimum necessary variables to describe the manpower reduction scenario will be included. The less complex the model the easier it should be to implement.

Relationships between variables and the expected functional values would be established by formulating and testing hypotheses. The goal is to define the system in terms of lineir inequalities which will then enable the linear programming method for solution. The weaknesses of these assumptions in the construction of the model and the results will be evaluated and interpreted.

The verification and validation can be chartered for the model results by a comparison to previous billet reductions. This procedure is to ensure the design consistency in the structure of the model. That is to confirm the model is a good representation of what was intended. The response of the model is compared with past observations to test the degree of fit. Sufficient departure from historical data will not necessarily invalidate data but rather promote discussion or revision of decision priorities. The most difficult part will be to minimize the weaknesses inherent in model building.

The implementation stage is the final process. Once accepted, a reduction quota will only be needed to initiate the model. The implementation of the model is predicated on the acceptance at the Headquarters level. The difficulty

lies in the administrative process required to distribute the technique. The critical factor will be the time lag that occurs between time accepted and the time field units receive the model or its subsequent changes. The model may become invalid if the time delay is large.

In summary, models are worthwhile if used in an appropriate manner. The various types of models and their strengths and weaknesses have been presented. The success of modeling as a research technique will depend on many variables and it is up to the researcher to understand those variables.

Formulation

Assumptions. The principal purpose of the prototype is demonstration of the application of a Linear Programming(LP) approach to defining data needs and solving manpower requirements. The construction of a model that simulates Security Force requirements to analyze different allocations is not a trivial task. Determining reductions is a related but separable problem from defining manpower standards at the headquarters level. This researcer understands that even if successful, there would always be a need for supplemental methodology to estimate requirements at various problem levels. The LP based approach offers the possibility of developing a working allocations system that could integrate standards as they become available and as they change. The model uses data and standards that might be

developed by the manpower planner at the problem location. Faced with constructing a prototype and purposely constraining it for micro-computer applications, this researcher relied essentially on existing data for input. The prototype concentrates solely on functional constraints. The logic and data for this military problem is intended to be straightforward.

Model Conventions. The mathematical definition of a linear program is presented in Appendix A. The prototype will be defined in that form. There is nothing unalterable about the formulation. Development of the model should be iterative where additions and enhancements occur as a consequence of gaining familiarity with the model. Iteration is possible as the model only theorizes a series of relationships that capture the relationships among people, functions, and type of dollar expenditures.

Model Constituents. The model is expressed in a form corresponding to the LP definition. This will be done by defining all variables, constraints, model coefficients, input data, and equations that comprise the model.

Variables. The LP technique describes a process of relationships among different elements. The relationships are our equations and the elements are the variables. Table 5 represents the variables used in defining and solving the problem.

Table 5.
Model Variables

Variable	Size	Definition
A	3	Number of billets requiring reduction in pay grade E-1
B	3	Number of billets requiring reduction in pay grade E-2
C	3	Number of billets requiring reduction in pay grade E-3
D	3	Number of billets requiring reduction in pay grade E-4
E	3	Number of billets requiring reduction in pay grade E-5
F	3	Number of billets requiring reduction in pay grade E-6
G	3	Number of billets requiring reduction in pay grade E-7

<u>Coefficients</u>. Table 6 defines the coefficient environment.

Table 6.
Coefficients

Variable	Size	Definition
A$	N	Wage authorization for E-1
B$	N	Wage authorization for E-2
C$	N	Wage authorization for E-3
D$	N	Wage authorization for E-4
E$	N	Wage authorization for E-5
F$	N	Wage authorization for E-6
G$	N	Wage authorization for E-7

<u>Input</u>. Before a user can exercise the model, the data that is specific to his organization must be collected. Input centers on the actual planned reductions, and any personnel limits that constrain the levels of the structural variables. Table 7 defines the user-specific information required to run the model.

Table 7.
Right Hand Side Variables

Variable	Size	Definition
Q(N)	N	Maximum allowable billet reduction
P(N)	N	Estimated billet reduction for E-1 across locations
PFC(N)	N	Estimated billet reduction for E-2 across locations
L(N)	N	Estimated billet reduction for E-3 across locations
C(N)	N	Estimated billet reduction for E-4 across locations
S(N)	N	Estimated billet reduction for E-5 across locations
SS(N)	N	Estimated billet reduction for E-6 across locations
G(N)	N	Estimated billet reduction for E-7 across locations
1(N)	N	Estimated billet reductions at location 1
2(N)	N	Estimated billet reductions at location 2
3(N)	N	Estimated billet reductions at location 3

Model Definition

The Objective Row. Given the potentially infinite number of feasible solutions to a problem stated in LP format, a mathematical relationship is necessary to find the best answer. This is referred to as the objective function and is important to the manpower planner because it controls the solution the LP process will compute. In the prototype, there were several ways to express an objective. The minimization of allocations was selected. The objective function follows:

A1 + A2 + A3 +

B1 + B2 + B3 +

$$C1 + C2 + C3 +$$

$$D1 + D2 + D3 +$$

$$E1 + E2 + E3 +$$

$$F1 + F2 + F3 +$$

$$G1 + G2 + G3 \qquad (1)$$

The above variables were defined in Table 5.

The Constraints.

Manpower Authorization. The first set of constraints assure that the total billet reduction does not exceed the quota authorized,

$$A1 + A2 + A3 +$$

$$B1 + B2 + B3 +$$

$$C1 + C2 + C3 +$$

$$D1 + D2 + D3 +$$

$$E1 + E2 + E3 +$$

$$F1 + F2 + F3 +$$

$$G1 + G2 + G3 \geq Q(n) \qquad (2)$$

where $Q(n=1,2,...N)$ = maximum allowable reduction. For this example, reductions are determined by higher headquarters.

Allocation by Grade. The key portion of this model is the translation of allocations into the expected grade components. The model allows the manpower planner to allocate reductions across the rank spectrum. This ensures that professional judgement enters into the equation and can be tracked as well. In this case, the manpower planner is limited to manpower reductions in the enlisted authorization. This limitation is by design. Officer reductions can

be similarly analyzed but are not because of the desire to retrofit a reduction methodology to existing requirements:

$$A1 + A2 + A3 \geq P(n) \qquad (3)$$

$$B1 + B2 + B3 \geq PFC(n) \qquad (4)$$

$$C1 + C2 + C3 \geq L(n) \qquad (5)$$

$$D1 + D2 + D3 \geq C(n) \qquad (6)$$

$$E1 + E2 + E3 \geq S(n) \qquad (7)$$

$$F1 + F2 + F3 \geq SS(n) \qquad (8)$$

$$G1 + G2 + G3 \geq G(n) \qquad (9)$$

where (n=1,2...N) = the estimated reduction by billet. The variables above were defined in Tables 5 and 7.

Allocation by Location. The model allows for reductions at each location to be set at an initial value. These constraining equations thus enhance the flexibility provided by Equations (3-9).

$$A1 + B1 + C1 + D1 + E1 + F1 + G1 \geq 1(N) \qquad (10)$$

$$A2 + B2 + C2 + D2 + E2 + F2 + G2 \geq 2(N) \qquad (11)$$

$$A3 + B3 + C3 + D3 + E3 + F3 + G3 \geq 3(N) \qquad (12)$$

Disposition of Earnings. This constraint allows analysis of monetary reductions in proportional/non-proportional reduction terms:

$$A\$*A1 + A\$*A2 + A\$*A3 \geq A\$*P(n) \qquad (13)$$

$$B\$*B1 + B\$*B2 + B\$*B3 \geq B\$*PFC(n) \qquad (14)$$

$$C\$*C1 + C\$*C2 + C\$*C3 \geq C\$*L(n) \qquad (15)$$

$$D\$*D1 + D\$*D2 + D\$*D3 \geq D\$*C(n) \qquad (16)$$

$$E\$*E1 + E\$*E2 + E\$*E3 \geq E\$*S(n) \qquad (17)$$

$$F\$*F1 + F\$*F2 + F\$*F3 \geq F\$*SS(n) \quad (18)$$

$$G\$*G1 + G\$*G2 + G\$*G3 \geq G\$*G(n) \quad (19)$$

The variables above are defined in Tables 5, 6, and 7.

Data Tables. As is the case in the development of any model, there is a requirement for data that comprise the structure of the model. The following paragraphs describe the data that was readily identifiable and relevant to the Linear Programming approach.

Billet Codes. Manpower and activities are defined by one specific military occupational specialty although the model has capacity to be defined by many. Identifying reduction requirements by one military occupational specialty allows the model to operate in the most basic problem environment.

Location Codes. The prototype organization is functionally and geographically dispersed. To simplify the prototype model, functional entities are geographically dispersed at one location each. Although function and location are the same in the prototype the model can expand a single function at multiple locations.

Wage Codes. Salaries from the most recent federal wage and earnings scale were used in the prototype as a check for output proportionality (8). Equations (9-15) permits the premise that a certain cutback percentage should be equitable across the wage and earning spectrum. The constraining equation provides the added flexibility of setting

nonproportional limits on each grade definition thus allowing the manpower planner with another weight factor.

Model Completion. The prototype has now been defined by its objective function, the equations or relations that show the interrelationships of the variables, and finally the variables themselves. All that remains to be done before submitting the problem for solution is to define the right hand side values which are particular to the organization.

Application

Initial Data. To demonstrate the general capabilities of the prototype, the Marine Barracks, Subic Bay, Republic of the Philippines, was chosen as a test case.

The Barracks is comprised of a Headquarters Company and three Guard companies. Nineteen officers and 611 enlisted men are authorized (29). Of the 611 enlisted men, 544 have the 8151(Guard) Military Occupational Specialty (29).

The Barracks Headquarters and Company A are located at the Subic Naval Station. The Headquarters provides command, control, and administration for the Guard Companies. Company A is responsible for perimeter security in the Subic area. The Naval Communications Link Station at Mt. Santa Rita also has a small security detail from Company A.

Company B is tasked with providing security aboard the Naval Air Station and Naval Magazine at Cubi Point. Company B mans 28 posts along 20 miles of shoreline and 53 miles of

roads. Like Company A they also patrol perimeter areas to deter and capture intruders and trespassers.

Company C is located at the US Naval Communications Station at San Miguel. Company C mans four fixed posts at San Miguel and two at the Naval Radio Transmitter Facility at Capas, in Tarlac province, approximately 15 miles north of Clark Air Base. Company C Marines also conduct patrols to deter intruder activity.

The Barracks was selected as data was readily available and the researcher was familiar with the location and the weight factors that might apply to the LP formulation. Note that these figures are not unalterable. In fact, the constraints that they imply may or may not be applied depending on the needs of the user. The data is presented in Table 8.

Table 8.
8151 Codes

GRADE	WAGES	LOCATION	ESTIMATED REDUCTION
A--E1	A$--8690	1--Subic	P(n)--3
B--E2	B$--9741		PFC(n)--0
C--E3	C$--11106		L(n)--1
D--E4	D$--12676		C(n)--0
E--E5	E$--14619		S(n)--0
F--E6	F$--16700		SS(n)--0
G--E7	G$--20984		G(n)--0
		2-Cubi Pt.	P(n)--1
			PFC(n)--5
			L(n)--2
			C(n)--1
			S(n)--0
			SS(n)--0
			G(n)--0
		3-San Miguel	P(n)--0
			PFC(n)--2
			L(n)--1
			C(n)--0
			S(n)--0
			SS(n)--0
			G(n)--0

Problem Generation. Having compiled the input data, defined the equations representing the model, and derived the coefficients of those equations, it now remains to put these data together in a form that a LP package on a micro-computer can understand.

The model was run on STORM, an integrated software package, from STORM Software, Inc. (6:1). STORM is a software application package that consists of quantitative modeling techniques for business and engineering problems. The mathematical models included in STORM are drawn from operations research/management science, operations management/industrial engineering, and statistics. The Linear and Integer Programming module is one of sixteen available on STORM.

STORM will run on IBM-PC,XT,AT, PS2 and 100% IBM compatible computers (6:2). The minimal amount of net memory is 256K bytes. STORM can be used on a system with one floppy disk drive, although two floppy drives or a fixed disk is recommended. STORM will operate with any of the standard monitors and printers currently used with the microcomputers identified above. DOS2.0 or higher is required. The package is representative of operations research packages currently available and easily installed on Government hardware.

Sample Results. The following paragraphs describe how a manpower planner might approach the manpower reduction problem. It proceeds step by step showing results and

indicating what the planner might observe. The figures that accompany the case description contain data extracted from the output reports of the model. The case is presented to show the method: further analysis and development is required before implementations could be considered.

Case 1. The planner determines a three percent reduction quota will be distributed among all grades in the 8151 MOS grouping. The distribution is to be allocated equally and must reflect a concurrent three percent monetary drawdown. The planner determines the monetary constraint can be expressed as a function of the annual wage earning for an average billet occupant. This scenario implements the input data presented in Table 9. STORM accepts the input data presented by Equations (1-19) in tabular format. STORM tabular input is presented in Appendix B. The solution is indicated in Table 9:

Table 9.
THESIS MODEL
DETAILED LP REPORT FOR
OPTIMAL SOLUTION

The following variables are fixed	
A1	4
B2	7
C3	3
D2	1
E2	1

The model output indicates a billet reduction of 4 Privates at Company A, 7 Privates First Class at Company B, 3

Lance Corporals at Company C, 1 Corporal at Company B, and 1 Sergeant at Company B. The output figures do not reflect a three percent reduction across ranks and location. The solution algorithm in STORM allowed for the weight criteria that was imposed by the average wage determination for each grade. Consequently STORM arrived at the optimal solution which minimized the billets in monetary terms. The output reflected the reduction of billets with the least earning impact.

Case 2. The planner determines a three percent reduction will be distributed to two of the three companies. The distribution will be allocated equally between companies A and C. The monetary constraint remains the same. Constraining equation (11) is redefined to block Company B from receiving reductions. Zero reductions should occur when the equation's Right Hand Side value is set to zero. The STORM tabular input is presented in Appendix B. The solution is indicated in Table 10:

Table 10.
THESIS MODEL
DETAILED LP REPORT FOR
OPTIMAL SOLUTION

The following variables are fixed

A1	4
B1	7
C3	3
D1	1
E1	1

The model output indicates a billet reduction of 4 Privates at Company A, 7 Privates First Class at Company A, 3 Lance Corporals at Company C, 1 Corporal at Company A, and 1 Sergeant at Company A. The output reflects reductions between the two companies which had the least earning impact.

Case 3. The planner determines that reductions must also be distributed within the proportions dictated by security force criteria in the Personnel Requirements Criteria Manual. According to the manual, the Corporal/Sergeant/Staff Sergeant ratio in a Security Force organization is 6/3/1. The additional requirement is incorporated in the model by the additional constraining equations:

$$F1 - 2*E1 \geq 0 \tag{20}$$

$$E1 - 3*D1 \geq 0 \tag{21}$$

$$F2 - 2*E2 \geq 0 \tag{22}$$

$$E2 - 3*D2 \geq 0 \tag{23}$$

$$F3 - 2*E3 \geq 0 \tag{24}$$

$$E3 - 3*D3 \geq 0 \tag{25}$$

The variables above were defined in Table 5. The STORM tabular input is presented in Appendix B. The solution is indicated in Table 11:

Table 11.
THESIS MODEL
DETAILED LP REPORT FOR
OPTIMAL SOLUTION

The following variables are fixed	
A1	4
B2	7
C2	2
C3	1
D3	1
E3	1

The model output indicates a billet reduction of 4 Privates at Company A, 7 Privates First Class at Company B, 2 Lance Corporals at Company B, 1 Lance Corporal at Company C, 1 Corporal at Company C and 1 Sergeant at Company C. The output reflects reductions which had the least minimum impact in criteria and earnings impact.

Case 4. The manpower planner determines that an additional MOS will be incorporated in the model. The reduction distribution will now include military police billets at Company A. The planner determines that these billets can be entirely eliminated. Deleting the MP billets up front thus lessens the reduction requirement for the Guard billets. The objective function must be expanded to include the additional requirement:

$$\begin{aligned} \text{Minimize} \quad & A1 + A2 + A3 + X1 + \\ & B1 + B2 + B3 + \\ & C1 + C2 + C3 + \\ & D1 + D2 + D3 + \\ & E1 + E2 + E3 + \\ & F1 + F2 + F3 + \\ & G1 + G2 + G3 \end{aligned} \tag{26}$$

Where X1 is the additional reduction requirement. Equation (2) must reflect the constraint change:

$$\begin{aligned} & A1 + A2 + A3 + X1 + \\ & B1 + B2 + B3 + \\ & C1 + C2 + C3 + \\ & D1 + D2 + D3 + \end{aligned}$$

$$E1 + E2 + E3 +$$

$$F1 + F2 + F3 +$$

$$G1 + G2 + G3 \geq Q(n) \quad (27)$$

An additional constraint must be included that sets the MP billet reduction at the desired level. The Marine Barracks Table of Organization for Company A indicates 5 billets can be eliminated. Equation (28) reflects the reduction constraint:

$$X1 = 5 \quad (28)$$

The Guard reduction is lessened by Equation (28) therefore the Right Hand Side values for Equations (3-7) and (10-17) can be lessened. The new Right Hand Side values are determined by proportionally distributing the remaining reductions. The tabular input is presented in Appendix B. The solution is indicated Table 12.

Table 12.
THESIS MODEL
DETAILED LP REPORT FOR
OPTIMAL SOLUTION

The following variables are fixed	
X1	5
A1	3
B2	4
C2	2
D3	1
E3	1

The model output indicates a billet reduction of 5 Military Police at company A, 3 Privates at Company A, 4 Privates First Class at Company B, 2 Lance Corporals at Company

B, 1 Corporal at Company C and 1 Sergeant at Company C. The output reflects reductions which required a military police reduction and had the minimum criteria and earnings impact.

Summary Comparison. Earnings and then security force criteria were the two features that essentially drove the analysis conducted above. The results of the first three cases versus actual reductions are presented in Table 13:

Table 13.
Model VS Actual Reductions
(Cases 1 - 3)

Company	Grade	Model Reduction	Actual Reduction
A	PVT	4/4/4	2
	PFC	0/0/0	0
	LCPL	0/0/0	2
	CPL	0/1/0	0
	SGT	0/1/0	0
B	PVT	0/0/0	1
	PFC	7/7/7	4
	LCPL	0/0/2	7
	CPL	1/0/0	0
	SGT	1/0/0	0
C	PVT	0/0/0	0
	PFC	0/0/0	0
	LCPL	3/3/1	0
	CPL	0/0/1	0
	SGT	0/0/1	0

As is evident the LP has not reproduced actual reductions. Actual reductions emphasized the need to reduce Lance Corporals and below while the model allowed reductions up to Gunnery Sergeant. The model could have omitted the Sergeant through Gunnery Sergeant allocations but would not then have indicated the true model potential. The ability

to model the grade spectrum for a specific MOS was instrumental for model success. The model, as presently configured, can be easily modified for emphasis on Lance Corporal and below billet reductions. The new model would require Right Hand Side figures for Sergeant through Gunnery Sergeant be set to zero. Further analysis might show the actual reductions can be precisely identified by other constraint equations. The precise interrelationship could thus be evaluated for merit rather than to only say a relationship exists.

IV Findings and Discussion

Overview

The purpose of this study was to develop a mathematical model for forecasting specific billets which should be reduced in a Marine Corps Security Force Organization once a quota is directed. This chapter will discuss how prototype LP model findings will support those objectives. A description of the model operations and a discussion of consistency/deviation from the plan will be presented first. An analysis of the model in terms of the original investigative questions will be presented. An analysis of sensitivity of the model to key variables will also be presented. The chapter will conclude with a discussion of the model's validity.

Model Operation

The Linear Program technique was chosen for problem resolution. The model was run on STORM, a PC application package that consists of Linear Programming and other quantitative modeling techniques for business and engineering problems.

Precise definition of the situational factors was imperative to model success. The managerial environment, in which the model may operate, requires technique, software, and hardware to be simple yet effective. To this end, the model functioned in a satisfactory manner. Software documentation is clear and logical. Microcomputer knowledge

required is minimum. Linear Programming does require an understanding of quantitative science techniques but is not beyond the reach of a manpower planner with a college level of mathematics and a good LP textbook.

The model was consistent with the purpose and objectives. There were no deviations from plans. The model did not result in any infeasible solutions. The potential for infeasible solution, however, does exist. The manpower planner must be constantly aware that constraints be properly formatted and logical with the model requirements.

Investigative Questions Analysis

The questions that focused the topic and were identified in Chapter 1 are answered and analyzed here:

1. What are the management science approaches to the Marine manpower problem? There are several approaches which may assist in organization reduction. Job Assignment Models, Job Element Models, Personnel Resource Allocation Models, Distribution Planning, and Mobility Planning Models are approaches to the job assignment/reduction process (23:226).

2. What in-house methodologies are currently employed to arrive at recommended cutbacks? Recommended cutbacks, at the Headquarters level, are determined by a Distribution Planning model run on a contractor mainframe computer (13). The headquarters model does not allow for weighted criteria. The model is a fair share distribution of cutbacks across

the grade and MOS spectrum. Brain-storming is the methodology employed at organization level to arrive at recommended cutbacks. There are no quantitative decision approaches employed at the organization level (13).

3. Why are the present methodologies used? The mainframe model has been in existence for approximately five years and is adequate for headquarter's needs (13). Brainstorming has traditionally been the only tool available at the organizational level to determine manpower cutbacks.

4. What are the various managerial science techniques that meet the requirements for employment? The Linear Programming technique is the only technique that meets the self-imposed requirements for employment. The strict requirements purposely narrowed the available techniques so 1) field implementation was possible and 2) adequate analysis would be possible.

5. Can constraint variables be identified and, if so, are they linear or non-linear? The identified constraint variables were linear. In mathematical terms, linearity implies a "constant return to scale" regardless of the level of input. The researcher does not negate the possibility of non-linear constraints. What is important is the technique achieve an adequate solution within clear and logical linear constraints.

6. Is the expertise for model formulation resident in the Marine Corps? Yes. This researcher, at a minimum, has the ability to implement the model at a Security Force

organization. Determination of others who have the required academic and organizational background is beyond the scope of this research; however, it is the opinion of this researcher that many Marine Personnel Officers probably have the educational background and reasoning ability to implement the model.

7. Is it cost-effective to train Marines in management science techniques or is it better to use outside agencies for model formulation, solution, and implementation? A cost-benefit analysis is beyond the scope of this research. Theorizing 1) contractor funds will be at a premium in the future and 2) model implementation is within the capability of some Personnel Officers; this researcher believes the potential exists for implementation of a rigorous management science technique at a bargain price. The bargain price would include costs necessary for the development of an in-house programmed text on Linear Programming and an outline of the personnel reduction methodology.

8. How can a cap on manpower organizations be estimated for an organization? A cap on manpower reductions is only as good as the manpower planner's justification. The justification is based on a perception of the ability for mission accomplishment. Mission accomplishment occurs because an organization is staffed according to manning criteria. Political influences may mandate reductions that result in below criteria manning. The Manpower Reduction Model's benefit is that it can quantify the manpower plan-

ner's justification. Such justification (LP mathematical interrelationships) can thus serve as the de-facto below criteria manning.

Sensitivity Analysis

Case 1 was the basic model. The model was then tested across environmental changes. Case 2 incorporated the requirement to change some of the Right Hand Side values. Case 3 incorporated an additional constraint. Case 4 incorporated an additional variable. The additional variable resulted in an additional constraint and different Right Hand Side values.

The additional cases highlighted the model's flexibility. Consequently, the manpower planner is afforded a valuable, "What if?" capability. A sensitivity analysis for a variety of managerial situations is possible if model changes reflect Linear Programming theory. The planning environment is only limited by the software's mechanical capability. The maximal and optimum problem size for STORM is 125 variables and 125 constraints (6:82). Case 4 required the most variables and constraints (18,25).

Model Validation

Grinold and Marshall argue that an important purpose of model building is to better understand a system and to act as an aid in thinking about important factors within a system (10:251). A model can thus help to highlight the important system forces by removing complex trivia. Grinold

and Marshall imply a model is valid when the user is convinced of its usefulness in a given situation (10:251). A model should not be designed to try to reproduce the whole system under every conceivable set of circumstances and events.

Grinold and Marshall contend a good model is one which allows the user to measure the effects, but at the same time is as simple as it can be (10:251). Grinold and Marshall attest no model can be valid under every set of conditions. Grinold and Marshall's attributes of a good model are:

> (1) It should be as simple as possible while employing enough decision variables to allow investigation of the desired policy changes.
> (2) It should be consistent with basic laws of conservation or physical laws and.
> (3) It should give reasonable answers which are satisfactory to the user when applied with decision variable values with which he is familiar. (10:251)

The Manpower Reduction model was conceived, formulated, and applied by the above attributes. Initial assessment is that the model is valid. This researcher concludes validity under Grinold and Marshall's claim that validity is achieved when the user is convinced of its usefulness in a given situation. This researcher believes the model will be extremely useful in assisting manpower planners determine reduction requirements.

Summary

This chapter described model operation and consistency/-deviation from original plans. An analysis of the model in

terms of the investigative questions was presented as well as analysis of the sensitivity of the model to key variables. The chapter concluded with an assessment of the model's validity.

V Conclusions and Recommendations

Overview

This chapter discusses the practical implications of the manpower model results. Next, the policy implications for management will be presented. The chapter will conclude with recommendations for refinement and adaptation.

Practical Implications

Model practicality was an important objective. Although several modelling techniques were available, the level of complexity of those modeling techniques precluded implementation. The imposed restrictions narrowed the approach to the LP technique on STORM. The prototype model, specifically defined, allows Security Force organizations the in-house capability to quantify manpower reduction requirements.

In general, one can make the following practical assessment of the prototype model:

1. The model forces the manpower planner to write down assumptions and build a mathematical system with real system constraints.

2. The model allows the manpower planner to discover system limitations, trends, or characteristics not apparent without the model.

3. The model offers the manpower planner the opportunity to prioritize and manipulate requirements without denying the use of local considerations to influence results.

4. The model can compare present and future manpower requirements.

5. The model can track many variables (manning criteria, earnings, function, and organization).

6. The model has the potential to consider all aspects and elements of the problem and thus offers the manpower planner a chance to make more informed decisions because he can now assess the total impact of a decision.

Policy Implications

The methodology described in this thesis can become a part of an organization's strategic and tactical planning processes. It is not intended to dominate those processes. The model can be a device to assist in the evaluation of policy. A manpower planner inputs data and assumptions and obtains a unique and perhaps optimal view of future system performance. The data can represent assumptions about the future and in many respects is a view of future manpower policy. The manpower planner is free to change the input data and explore a broad range of policy alternatives. If the planning process is viewed this way the model then becomes the heart of a policy simulation or policy exploration process. Policy simulation and exploration are pro-active processes which should be fundamental to an organization's planning activities. The organization can thus achieve timely and strategic responses to changing conditions. The United States Marine Corps can be responsive in

the downsizing environment and obtain a greater level of effectiveness and efficiency.

Recommendations

The prototype model was not expected to reproduce the actual reduction figures. Perhaps better relations at more detailed levels could be derived. In the end, however, the manpower planner will have to consider tradeoffs among detail, applicability, and validity. The model, nevertheless, illustrated the type of information and analysis that is possible.

Field implementation is possible but should occur only after review and analysis at Headquarters. This researcher believes the prototype model can be further validated by Headquarters manpower analysts. Headquarters can refine the model prototype into a mature modeling system. A mature model can then be passed to the field organizations. Model simplicity allows minimum documentation requirements. Documentation can take the form of correspondence, personnel manual appendices, or technical instructions.

Summary

As Grinold and Marshall attest, model building, validation and use are an art, though scientific method enters the model (10:252). Practicality, however, is the key to model success. Practical and policy implications of the model were discussed in this chapter. Recommendations for refinementand adaptation were also presented.

Appendix A: Linear Programming Theory

The Linear Program Problem

The linear program (LP) is one of the general problem class called mathematical programs. The LP is generally stated in the following way:

$$\text{maximize or minimize } f(x) = cx$$

$$\text{subject to } Ax = b \text{ and } x \geq 0$$

Where A is an m x n matrix; b is an m-vector; and c, x, and 0 are n-vectors.

For those unfamiliar with matrix notation, the above can also be stated as follows:

$$\text{maximize } c(1)*x(1)+c(2)*x(2)+.....+c(n)*x(n)$$

subject to

$$a(1,1)*x(1)+a(1,2)*x(2)+.....+a(1,n)*x(n) = b(1)$$

$$a(2,1)*x(1)+a(2,2)*x(2)+.....+a(2,n)*x(n) = b(2)$$

$$\vdots$$

$$a(m,1)*x(1)+a(m,2)*x(2)+.....+a(m,n)*x(n) = b(m)$$

$$\text{with } x(i) \geq 0 \quad i=1,n.$$

The function f(x)=cx to be maximized is called the objective; the matrix A is called the constraint matrix; and b, as a result of its placement is called the right-hand side. Simply stated, the LP seeks to determine what variables x(1), x(2),..., and x(n) must take for f(x) to be its lowest value, while at the same time assuring that the equations defined by Ax=b still hold and with the additional stipula-

tion that each variable x(i) is either positive or equal to zero. Since the variables x(i) are neither raised to a power (e.g., squaring x(i)) or cross-multiplied (as in the familiar quadratic equation where $(x-1)*(y-x)=xy-y+x-x^2$)), all relations and equations are linear representations of the variable and the constants found in c and A.

Application

Linear Programming subsumes both the problem formulation and the process used to solve it. In problems where there can be hundreds of rows within the constraint matrix and possible hundreds of variables to consider (where each can take on any value between zero and infinity), it would tax the ability of one or more individuals to determine which of the many solutions is optimal. An algorithm, however, exists that arrives at an optimal solution (assuming one exists). The simplex algorithm (and its variations) is an important tool that has arisen in the field of operations research. While providing a mechanism for an efficient solution search, it does, however incur a rather computational burden. Even small problems require too much time if done by hand. If not for the availability of computers, the simplex algorithm would be theoretically elegant but of little practical importance in solving all but the most simple problems. Research into efficient computer codes has enabled researchers to obtaing LP packages for most mainframe, mini, and micro-computer systems. Problems of hundreds and even thousands of rows can be solved in minutes.

Summary

It is not the purpose of this appendix to be a Linear Programming tutorial. There are several texts that can serve as starting points. LP texts can be found under the Management Science/Operations Research/Quantitative Decision Making holdings in most libraries.

The purpose of the appendix was to provide a general framework for which the reader could become familiar with Linear Programming technique.

Appendix B: STORM Data Input

Case 1

Table 14.
Case 1 Data

```
@LP : THESIS MODEL
 21 18 YES  MIN
A1          A2          A3          B1          B2          B3          C1
C2          C3          D1          D2          D3          E1          E2
E3          F1          F2          F3          G1          G2          G3
CONST TYPE R H S        RANGE
OBJ COEFF  1 1 1 1 1 1 1 1 1 1 1 1 11 1 1 1 1 . 1 1 1 XXXX XXXX XXXX
Q(N)       1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 >=   16 .
P(N)       1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   4 .
PFC(N)     0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   7 .
L(N)       0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 >=   3 .
C(N)       0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 >=   1 .
S(N)       0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 >=   1 .
SS(N)      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 >=   0 .
G(N)       0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 >=   0 .
A$P(N)     8690 8690 8690 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   34760 .
B$PFC(N)   0 0 0 9741 9741 9741 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   68187 .
C$L(N)     0 0 0 0 0 0 11106 11106 11106 0 0 0 0 0 0 0 0 0 0 0 0 >= 33318  .
D$C(N)     0 0 0 0 0 0 0 0 0 12676 12676 12676 0 0 0 0 0 0 0 0 0 >=   12676  .
E$S(N)     0 0 0 0 0 0 0 0 0 0 0 0 14619 14619 14619 0 0 0 0 0 0 >=   14619  .
F$SS(N)    0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 16700 16700 16700 0 0 0 >=   0 .
G$G(N)     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 20984 20984 20984 >=   0 .
1(N)       1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 >=   4 .
2(N)       0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 >=   9 .
3(N)       0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 >=   3 .
VARBL TYPE IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS
       IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS XXXX XXXX XXXX
LOWR BOUND 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 XXXX XXXX XXXX
UPPR BOUND . . . . . . . . . . . . . . . . . . . . . XXXX XXXX XXXX
INIT SOLN  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 XXXX XXXX XXXX
```

Case 2

Table 15.
Case 2 Data

```
@LP : THESIS MODEL
 21 18 YES  MIN
A1          A2          A3          B1          B2          B3          C1
C2          C3          D1          D2          D3          E1          E2
E3          F1          F2          F3          G1          G2          G3
CONST TYPE R H S        RANGE
OBJ COEFF  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 XXXX XXXX XXXX
Q(N)       1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 >=  16 .
P(N)       1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=  4 .
PFC(N)     0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=  7 .
L(N)       0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 >=  3 .
C(N)       0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 >=  1 .
S(N)       0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 >=  1 .
SS(N)      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 >=  0 .
G(N)       0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 >=  0 .
A$P(N)     8690 8690 8690 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=  34760 .
B$PFC(N)   0 0 0 9741 9741 9741 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=  68187 .
C$L(N)     0 0 0 0 0 0 11106 11106 11106 0 0 0 0 0 0 0 0 0 0 0 0 >=  33318  .
D$C(N)     0 0 0 0 0 0 0 0 0 12676 12676 12676 0 0 0 0 0 0 0 0 0 >=  12676  .
E$S(N)     0 0 0 0 0 0 0 0 0 0 0 0 14619 14619 14619 0 0 0 0 0 0 >=  14619  .
F$SS(N)    0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 16700 16700 16700 0 0 0 >=  0 .
G$G(N)     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 20984 20984 20984 >=  0 .
1(N)       1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 >=  4 .
2(N)       0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 >=  0 .
3(N)       0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 >=  3 .
VARBL TYPE IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS
      IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS XXXX XXXX XXXX
LOWR BOUND 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 XXXX XXXX XXXX
UPPR BOUND . . . . . . . . . . . . . . . . . . . . . XXXX XXXX XXXX
INIT SOLN  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 XXXX XXXX XXXX
```

Case 3

Table 16.
Case 3 Data

```
@LP : THESIS MODEL
 21 24 YES  MIN
A1          A2          A3          B1          B2          B3          C1
C2          C3          D1          D2          D3          E1          E2
E3          F1          F2          F3          G1          G2          G3
CONST TYPE R H S        RANGE
OBJ COEFF  1 1 1 1 1 1 1 1 1 1 1 1 11 1 1 1 1 1 1 1 1 XXXX XXXX XXXX
Q(N)       1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 >=   16 .
P(N)       1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   4 .
PFC(N)     0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   7 .
L(N)       0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 >=   3 .
C(N)       0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 >=   1 .
S(N)       0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 >=   1 .
SS(N)      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 >=   0 .
G(N)       0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 >=   0 .
A$P(N)     8690 8690 8690 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   34760 .
B$PFC(N)   0 0 0 9741 9741 9741 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   68187 .
C$L(N)     0 0 0 0 0 0 11106 11106 11106 0 0 0 0 0 0 0 0 0 0 0 0 >=   33318   .
D$C(N)     0 0 0 0 0 0 0 0 0 12676 12676 12676 0 0 0 0 0 0 0 0 0 >=   12676   .
E$S(N)     0 0 0 0 0 0 0 0 0 0 0 0 14619 14619 14619 0 0 0 0 0 0 >=   14619   .
F$SS(N)    0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 16700 16700 16700 0 0 0 >=   0 .
G$G(N)     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 20984 20984 20984 >=   0 .
1(N)       1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 >=   4 .
2(N)       0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 >=   9 .
3(N)       0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 >=   3 .
CPL/SGT1   0 0 0 0 0 0 0 0 0 0 0 0 0 -2 0 0 1 0 0 0 0 >=   0 .
SGT/SSGT1  0 0 0 0 0 0 0 0 0 0 -3 0 0 1 0 0 0 0 0 0 0 >=   0 .
CPL/SGT2   0 0 0 0 0 0 0 0 0 0 0 0 0 -2 0 0 1 0 0 0 0 >=   0 .
SGT/SSGT2  0 0 0 0 0 0 0 0 0 0 -3 0 0 1 0 0 0 0 0 0 0 >=   0 .
CPL/SGT3   0 0 0 0 0 0 0 0 0 0 0 0 0 -2 0 0 1 0 0 0 0 >=   0 .
SGT/SSGT3  0 0 0 0 0 0 0 0 0 0 -3 0 0 1 0 0 0 0 0 0 0 >=   0 .
VARBL TYPE IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS
       IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPO  XXXX XXXX XXXX
LOWR BOUND 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 XXXX XXXX XXXX
UPPR BOUND . . . . . . . . . . . . . . . . . . . . . XXXX XXXX XXXX
INIT SOLN  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 XXXX XXXX XXXX
```

Case 4

Table 17.
Case 4 Data

```
@LP : THESIS MODEL
 22 25 YES  MIN
X1          A1          A2          A3          B1          B2          B3
C1          C2          C3          D1          D2          D3          E1
E2          E3          F1          F2          F3          G1          G2
G3          CONST TYPE R H S      RANGE
OBJ COEFF  1 1 1 1 1 1 1 1 1 1 1 1 1 11 1 1 1 1 1 1 1 1 XXXX XXXX XXXX
Q(N)       1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 =    16 .
P(N)       0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   3 .
PFC(N)     0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   4 .
L(N)       0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 >=   2 .
C(N)       0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 >=   1 .
S(N)       0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 >=   1 .
SS(N)      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 >=   0 .
G(N)       0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 >=   0 .
A$P(N)     0 8690 8690 8690 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=  26070  .
B$PFC(N)   0 0 0 0 9741 9741 9741 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=  38964  .
C$L(N)     0 0 0 0 0 0 0 11106 11106 11106 0 0 0 0 0 0 0 0 0 0 0 0 >=  22212 .
D$C(N)     0 0 0 0 0 0 0 0 0 0 12676 12676 12676 0 0 0 0 0 0 0 0 0 >=  12676 .
E$S(N)     0 0 0 0 0 0 0 0 0 0 0 0 0 14619 14619 14619 0 0 0 0 0 0 >=  14619 .
F$SS(N)    0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 16700 16700 16700 0 0 0 >=  0 .
G$G(N)     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 20984 20984 20984 >=  0  .
1(N)       0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 >=   3 .
2(N)       0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 >=   6 .
3(N)       0 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 >=   2 .
CPL/SGT1   0 0 0 0 0 0 0 0 0 0 0 0 0 0 -2 0 0 1 0 0 0 0 >=   0 .
SGT/SSGT1  0 0 0 0 0 0 0 0 0 0 0 -3 0 0 1 0 0 0 0 0 0 0 >=   0 .
CPL/SGT2   0 0 0 0 0 0 0 0 0 0 0 0 0 0 -2 0 0 1 0 0 0 0 >=   0 .
SGT/SSGT2  0 0 0 0 0 0 0 0 0 0 0 -3 0 0 1 0 0 0 0 0 0 0 >=   0 .
CPL/SGT3   0 0 0 0 0 0 0 0 0 0 0 0 0 0 -2 0 0 1 0 0 0 0 >=   0 .
SGT/SSGT3  0 0 0 0 0 0 0 0 0 0 0 -3 0 0 1 0 0 0 0 0 0 0 >=   0 .
MP         1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 >=   5 .
VARBL TYPE POS  IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS
       IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS IPOS XXXX XXXX XXXX
LOWR BOUND . 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 XXXX XXXX XXXX
UPPR BOUND . . . . . . . . . . . . . . . . . . . . . . XXXX XXXX XXXX
INIT SOLN  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 XXXX XXXX XXXX
```

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VITA

Captain Norman P. Schaefer [redacted] graduated from Notre Dame High School in Biloxi, Mississippi in 1979. He then attended Mississippi State University on an AFROTC scholarship where he received the degree of Bachelor of Science in Industrial Engineering in May 1983. Upon graduation, he was commissioned a Second Lieutenant in the Air Force. His first assignment was with the 3800th Civil Engineering Squadron at Maxwell AFB, Alabama where he served as the Assistant Chief of the Industrial Engineer Branch and then as the Squadron Section Commander until December of 1985. He was then transferred to the 343rd Civil Engineering Squadron at Eielson AFB, Alaska where he was the Chief of the Industrial Engineering Branch until May 1989. While at Eielson AFB, he was also the Officer-in-Charge (OIC) of the Alaskan Air Command's (AAC) Readiness Challenge Team in 1987. In that capacity, he and his team represented AAC at the worldwide competition which was held at Field Four, Eglin AFB, Florida in December of 1987. He entered the Graduate Engineering Management (GEM) Program at the School of Systems and Logistics, Air Force Institute of Technology (AFIT), in May 1989.

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13. ABSTRACT (*Maximum 200 words*)
The United States Marine Corps has a charter to restructure manpower. The charter is the primary result of a change in command philosophy about how the Marines wage war but is tempered within the constraints of a declining force. The reduction and redistribution of forces are important issues. This study investigated the Linear Programming technique as a methodology to forecast billet reductions in one Marine Corps organization. The mathematical model allows weighted criteria to be incorporated into the reduction equation. A sensitivity analysis shows how the limits of the model variables can affect the optimum solution. The general capabilities of the model were indicated when data from the Marine Barracks, Subic Bay, Republic of the Philippines were tested across four manpower planning cases. The model was formulated on existing management science software so local commanders can use the model at their unit. Although the prototype did not reproduce already planned reductions, the model illustrates the type of information and analysis that is possible.

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